Tensions in Design Principle Formulation and Reuse

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Abstract. Designing can be viewed as a collective activity that accumulates and reuses knowledge over time and, in the information systems field, such knowledge often takes the form of design principles. While design principles are now a predominant from to capture, accumulate, and reuse design knowledge, their reusability cannot be taken for granted. In this paper, we present the preliminary findings of an ongoing series of experiments that aim to explore the characteristics of design principles that facilitate or inhibit their reuse. Our preliminary findings suggest that, interestingly, these characteristics occur as contradicting elements. We situate the tensions in the light of hermeneutics, expert intuition, and C-K design theory. We hope that, through our ongoing work, we can trigger further discussion on design principles reuse in the DSR community.

Keywords: Design principles · Knowledge reuse · C-K design theory

1 Introduction

It is not an overstatement to consider designing as a fundamental human activity, since we use it in various life domains, from solving problems and exploring the unknown territories in the universe to creating our future for better or worse [1]. Good design can go far beyond a single success story. Once the knowledge that underlies a specific design is captured in a sufficiently abstract way, it can inform other design endeavors in similar areas. On this view, designing is a collective activity that accumulates and reuses design knowledge over time. In the Information Systems (IS) field, design principles are now a predominant way to capture, accumulate, and reuse design knowledge [2, 10]. They have been defined as "knowledge about creating other instances of artifacts that belong to the same class" [3, p. 39].

As is the case for other forms of knowledge, design principles can be reused as they are, but designers can also modify or recombine them with other forms of abstract and practical knowledge [4]—and reuse can be facilitated by enhancing the reusability attribute of the design knowledge itself [5]. Therefore, we ask, *what characteristics can enhance the reusability of design principles?*

In this research-in-progress paper, we present and discuss the preliminary findings of a study that is part of larger series of experiments, with the main goal of addressing this question.

Interestingly, our preliminary findings suggest that the design principles formulated by expert designers are *rich in tensions and contradictions,* and they give us important insight about the reuse of design principles. By focusing on the characteristics of design principles, we contribute to the ongoing debate on how design principles should be formulated and used in IS [9, 30]. Notably, the characteristics of design principles have gained increased attention in various disciplines, such as educational technology [6], mechanical design [7], organizational design [8], and indeed IS [9]. Before presenting our preliminary findings and our discussion, we first characterize the key concepts and briefly describe the overall research design and more specific research procedures. We conclude with a brief outlook on future studies that aim at addressing the characteristics of reusable design principles in IS.

2 Characterizing Design and Design Principles Reuse

2.1 Design and Redesign

The analysis of design activities has undergone several paradigm shifts over the past years. Initially seen as being similar to decision making and problem solving [10] and structured into a process that emphasizes objectivity and rationality—what Cross [11, p. 1] dubbed "scientised" —design problems have been identified as wicked problems [12, 13] that call for a different approach. The last decades saw the turn into viewing design as a reflective practice [14-16] and an expandable rationality [17]. Considered a reflective practice, design incorporates both technical knowledge and artistry and occurs as a reflective conversation between designers, their actions, and their situations [14]. Seen as an expandable rationality—an extension of Simon's concept of bounded rationality—design should not be reduced to problem solving, even though it involves problem solving [17]. Therefore, design is both rational and reflective [16, 18].

In spite of the differences between various approaches employed in studying design, all of them tend to follow complementary traits or logics of design [19]. These traits can be summarized as "recognition of the unknown, propagation of the concept based on available knowledge, and generation of new concepts" (p. 4). Design is also viewed as redesign [e.g., 20], because it "is never a process that begins from scratch […] There is always something that exists first as a given, as an issue, as a problem" [21, p. 5]. This argument, however, is not to be confused with the notion of redesigning by users [cf. 22, p. 99] that rather deals with product adjustments or uses that differ from the intention of its designer.

2.2 Design Principle Reuse

We argue that *design knowledge* is passed from one (re)design situation to another. Design knowledge is generally defined as the knowledge "of and about the artificial world and how to contribute to the creation and maintenance of that world" [23, p. 6]. Such knowledge is

gained by engaging in the activity of designing and producing artifacts, as well as by reflecting upon and using those artifacts [23].

As is the case for other forms of knowledge, design principles can be reused as they are, but designers can also modify or recombine them with other forms of knowledge [4]. Even though reusing is often seen synonymous to repetition, reuse has been observed in contexts where innovation is the main goal [24, 25]. In reuse, design principles are often treated as "guidelines for making design decisions" and guidelines in navigating "through the design space and obtain an effective design" [24, p. 67]. Knowledge reuse can be facilitated by enhancing the reusability attribute of the design knowledge itself (e.g., capturing and documenting knowledge) or making knowledge transfer among designers easier (e.g., developing and maintaining good repositories for knowledge dissemination [5]). For knowledge reuse to take place, a community of practice needs to share a common knowledge base, which can also be assumed for the designer community [26]—including the IS field. The focus of this research is on inferring what specifically matters about design principles that makes them effectively reusable for designers.

2.3 Tensions and Paradoxes in Design and Design Principles Reuse

Paradoxes embrace "contradictory yet interrelated elements [27]—elements that seem 'logical' in isolation but absurd and irrational when appearing simultaneously [28, p. 760]. In this paper, we utilize the notion of tension to soften the claim of something being a paradox. Prominent scholars have noted that design is "nothing if not full of paradoxes and contradictions. Divergent and convergent thinking are at its core. The new and the old. Letting the mind wander and focusing it" [22, p. 7]. Some even went on to define design as "the resolution of paradoxes between discourses in a design situation" [16, p. 17]. Similarly, IS DSR scholars have identified the ambiguity of the word "design," that is both a verb and a noun [e.g., 29]. The basic trait of design theory —and thus design principles—has even been put forward as the "creation of the language of the unknown and generativity" [19, p. 5], which again indicates a tension of known/unknown at work. Against this background, we postulate that design principles reuse contains tensions and even paradoxes. *The first step towards enlightenment, we argue, is therefore the recognition of the tensions and paradoxes to be resolved in order to enhance the reusability of design principles.*

3 Method

3.1 Overview of Research Design

This research continues the collective attempt to understanding what makes up design principles in IS [e.g., 9] and through which mechanisms designers reuse design principles [e.g., 30]. Inspired by Barbara Tversky's works with her colleagues on designing instructions [e.g., 31, 32], this research is designed as a series of experiments that can be summarized in

three key stages: (1) production of design principles; (2) formulation preference; and (3) output comparison. Due to space restriction, this paper only elaborates on the design of the first study and reports on its preliminary findings.

3.2 Production of Design Principles

The voluntary participants in our study on the production of design principles (i.e., the first in a series of three key studies) are User Interface (UI) designers with several years of experience, who speak English in their professional setting. We provided the participants with a smartphone with an energy conservation application (app), two sheets of paper, two pens, and a box of coloring pencils. The particular app was selected for its high user rating and intuitive design and because its domain is not too familiar, so that the participants still need to think and reflect when completing the task.

The participants were first asked to use the already launched app on the smartphone given to them in any way they felt comfortable with. They were given the task to understand what the app is for, how it is designed, and what users can do with it. They were also specifically asked to think about how they can design a similar app. Next, they were asked to produce a set of design principles that is aimed at UI designers like themselves. We gave the participants neither time constraint nor brevity constraint in completing the task. The instruction goes as follows [adapted from 32]:

> "Suppose other User Interface (UI) designers want to design a similar app and ask you for advice. Please write some guidelines to help them designing the app, so that they can make their design decisions efficiently. You can use a combination of pictures and words. The pictures can be sketches; there is no need to worry about the way they look, as an artist will do the actual drawings. Please ensure that the guidelines are straightforward and easy to understand by your fellow designers."

4 Tensions and Paradoxes in Design Principles (DP) Formulation and Reuse

4.1 A Brief Summary of Preliminary Analysis and Findings

At the time of writing this research-in-progress paper, we have collected four sets of design principles from practicing designers (referred to as D1, D2, D3, and D4) with at least five years of professional experience. In accordance with the exploratory nature of this study we tried to identify similarities and differences among the four sets of design principles, as well as among the individual sets of design principles, without any predefined rules. Due to the brevity constraint, we summarize the preliminary findings as the following contradicting elements and discuss them in light of several theoretical narratives.

#1 Mapping problem space vs. solution space: D1 and D3 said much about the app features (e.g., "illustrate the savings-level of the user with a photo"), while D2 and D4 also considered the user's perspective (e.g., "show and track how much energy, trees and water [people] saved with their actions"). The former corresponds to the solution space, while the latter to the problem space. These tendencies and their potential implications have been discussed in depth in [9].

#2 Design principles as rules vs. lessons learned: While most of the proposed guidelines are rule-like (i.e., they are based on what works well in the current app and other proofs-of-concept), we found some to be strikingly intuitive (e.g., "gamification makes the app interesting" and "don't let people add as many activities as they want because they can lose the motivation to do any of them looking at the long list" by D4). The latter statements are rooted in expertise intuition gained by accumulating lessons learned in doing design. A similar distinction has been put forward in [33].

#3 Positive vs. negative knowledge: Two of our participants (D3 and D4) proposed how to improve the app design. While D3 suggested incremental improvement (such as the presentation of activities as push cards), D4 began critiquing the current design and stating guidelines on *what not to do* (e.g., "don't put the formulas (calculation) on the app but on a separate webpage") before saying *what to do*.

#4 Design principles in pure textual form vs. in combination with visual cues: While not being strictly paradoxical in nature, participants' preference in using only text or a combination of text and sketch is worth noticing. Recall that all participants were given the same instruction (Section 3.2). We observed only very slight differences in the text lengths, where the standalone ones were slightly longer (by D3 and D4) and more elaborate than those that were in combination with sketches (by D1 and D2).

4.2 Discussion

What are the implications of these preliminary findings in the discourse of design principle formulation and reuse? In the following sections, we address this question in light of some established streams of thought.

DP Formulation and Reuse in Light of Hermeneutics

It has been suggested that the first act of understanding takes the form of a guess [34]. This means, "we have to guess the meaning of the text because the author's intention is beyond our reach" (ibid). The important step comes thus after guessing, namely the validation of the guess. The validation is not necessarily an empirical verification that leads to a true/false conclusion, but rather showing that "an interpretation is more probably in the light of what we know" (p.76).

This idea can be applied to describe how a designer reuses design principles that are formulated in textual form. We can argue that reusing begins with understanding, which in turn starts with guessing the essential knowledge that can be derived from the design principles

and followed by a validation of the guess. A similar idea was also captured in Nonaka and Takeuchi's [35] SECI portrayal of knowledge dimensions and the dynamics among them. Using their terms, what Riceour has proposed can be restated as follows. The knowledge gained through and employed throughout designing is crystallized in a set of design principles. When other designers try to reuse the knowledge, they first internalize the design principles, combine them with their expertise and experience, and then generate new concepts to be applied into their design situation. But in how far does the expertise matter?

DP Formulation and Reuse, Best Practices and Expert Intuition

The debate between the importance of best practices (rules) drawn from evidence versus expert intuition has been going on among cognitive scientists [36]. Rules and expert intuition often contradict each other. On the one hand, rules are considered "an important opportunity for any community to shed outmoded traditions and unreliable anecdotal procedures" since "they enable organizations to act in a consistent way" [37, p. 253]. On the other hand, the same authors expressed their concern that "practitioners in a variety of disciplines may have trouble gaining expertise if they just mechanically apply prescribed rules" [37, p. 250]. Applying the tension to our preliminary findings, we can say that even though design principles can contribute to enhanced reliability of the design outcome, we need to find a right balance between design principle reuse and reliance on designers' expertise in order to avoid unreliable procedures on the one hand and not to constrain innovation on the other. This line of thinking is consistent with the common approach of managing codified knowledge in a learning organization that keeps a healthy amount of tacit knowledge [e.g., 38].

C-K Design Theory and DP Formulation and Reuse

The C-K design theory was proposed by Hatchuel and Weil [39, 40] with the goals of offering a clear and precise definition of design and going forward from the idea of design being nothing else than problem solving to design as being an integration of creative thinking within problem solving. According to this theory, design happens in two spaces—a knowledge space (K) and a concept space (C). All propositions of K have a logical status (true or false), while the propositions in the C space have no logical status in a space K and have a tree based structure.

Design is then defined as (a) the process "by which a concept generates other concepts or is transformed into knowledge, i.e., propositions in K" [40, p. 5] and (b) the process "by which K→C disjunctions are generated, then expanded by partition or inclusion into C→K conjunctions" (p. 8). Please consult [39, 40] for an in-depth explanation. This theory postulates two types of creativity (p. 12): *C-k* creativity or a "conceptual innovation" that involves adopting daring concepts but then quickly looking for new knowledge expansion outside the team; *c-K* creativity or an "applied science" where one adopts an acceptable concept that is not too daring, and is determined to persevere in developing the concept into a creative design.

The proponents of the C-K theory once asked, "what is the impact of knowledge codification on the ability to design?" [40, p. 13]. We can address this question by putting the C-K theory into the phenomenon of designers reusing design principles. On the one hand, we expect to find *c-K* creativity, because available design principles add to designers' K space. In this case, designers already know what works well and can therefore apply the knowledge in attaining their goals. Nevertheless, this conjecture only holds given that we assume design principles to have a logical status following a rigorous validation and thus being part of the K space (i.e., rule-based). If design principles are assumed to be propositions in the C space (i.e., lessons learned), on the other hand, we can expect to see either a conceptual innovation (*C-k)* or simply a design activity that is not innovation-oriented. This tension will be addressed in our future studies.

5 Conclusion and Outlook

Good design can go far beyond a single success story. Once the underlying knowledge is captured, it can inform other design endeavors in similar areas. Design principles are an appropriate vehicle to disseminate knowledge contributions of design science research (DSR) endeavors [10], and it is thus important to account for artifacts' instantiation validity [11, 12] and the reusability of design principles. Through this paper, we would like to kindle a discussion in the DSR community on the characteristics of reusable design principles or design theory [41, 42]. We took a first step by illuminating the contradicting elements in design principles formulation and by discussing the possible implications for design principle reuse in light of hermeneutics, expert intuition, and C-K design theory. Our ongoing and further research follows the previously discussed research design—we will empirically compare and contrast the contradicting elements of design principles in terms of designers' preference (stage 2: formulation preference) and the resulting design process and products (stage 3: output comparison). We hope that this research will make a contribution to developing a strong body of prescriptive knowledge in IS that is reusable and actionable.

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